

### **Strategic Roadmap Focus Area 8: Exploration of the dynamic Earth system**

There have been significant efforts over the last decade to formulate an earth science vision to guide the definition of successors to the great EOS observatories. These observatories are now demonstrating the significance of an integrated “global” approach to understanding the complex interactions of earth systems. In planning for the next generation, we must focus on expanding the measurements from snapshots to the capability of monitoring the evolution of significant events, whether they are volcanic eruptions, storms or significant gaseous or particulate emissions. Detailed implementation of this evolution should flow from potential benefits that we, as a science community, create in providing factual information to help government and industry make informed decisions. What is the vision for earth science?

One aspect is incorporation of a persistent observation capability to provide more frequent, higher spatial resolution EO observations from GEO. A second aspect is the development and implementation of advanced information systems and improved standards for collection, storage, processing and distribution of large data volume, as described below.

Other aspects could include:

All weather land/ocean imaging with persistence (radar)  
Atmospheric profiling with high resolution on a global scale using either vertical (active and/or passive) sensing or limb-viewing  
Significant in situ capability integrated with satellite data collection and redistribution  
Models with improved initializations and coupling to other domains  
Standards

First, consider advancements in Earth observation. The availability of precision state measurements from improved geo-based spectral EO systems (i.e., large area, persistent coverage from geo-synch orbit) for land, sea and atmosphere is strongly recommended as an objective for the next generation of earth observation satellites. Persistent observations will allow monitoring of the temporal evolution of significant events. It will also enable spatially contiguous coverage, beyond what multiple MODIS instruments can do on the current systems. As we move to a system of carbon accounting, it can provide the foundation for factual verification of environmental actions. Both filled aperture and dilute aperture systems can be employed, with the latter able to provide the best resolution per unit of mass put into orbit. One regret of these approaches is that they make each observation at different sun times, thereby losing the ability to monitor changes under the lighting conditions, as is provided by sun synchronous systems.

The creation of a precision and persistent state observation system can be evolutionary.  
1. Multispectral Systems. The first step should be a multispectral system with bands for land and ocean measurement. These bands should be selectable to cover the applications within the pointing volume at a given instant. Systems would provide ocean and land monitoring with resolutions of 30m. Telescopes for this application are within the state of the art and communication systems are evolving to support the data flow. Satellite

performance characteristics will need to evolve. A proof of concept system could be built now.

Hyperspectral Systems. The next step could be a hyperspectral system that extends the multispectral capability to provide more detailed spectral characteristics for monitoring.

Ultraspectral Systems. These systems will address the details of atmospheric (and surface) chemistry with a spatial resolution and spectral detail that will revolutionize aspects of space-based remote sensing. There may be a need with this instrument to trade some spatial resolution for signal to noise, but that will be less of an issue as focal plane performance improves. These instruments are now being built for low earth orbit and elsewhere.

Linked systems. As onboard and other technologies improve, formation flying at GEO can create a partially filled aperture to enhance resolution without further stressing large aperture technology. The signal to noise penalty may be compensated for by going to super conducting sensors.

All of the advances in sensors will create vast quantities of data. An effective and efficient information management system is critical to support the next generation of observations systems. A new framework for information technology has emerged in the worlds of commerce and defense: network-centric operations. This framework is suitable for future generations of Earth science. Starting in 2003, the capabilities developed for DOD and air traffic management has been incorporated into a series of demonstrations on the efficacy of NCO information systems for science and research. Besides the obvious economic benefits to the Nation, these experiments show potential for greatly improved understanding and modeling of fine-scale phenomena in the atmospheric boundary layer and on the land and ocean surfaces.

These experiments were enabled by recent advances in technology for network-centric operations. The key attribute of a network-centric approach is interoperability – the ability of diverse, distributed information systems to work together in ad hoc combinations. Interoperability is more than connecting systems to a high-speed network. By using web-oriented services and publish-subscribe mechanisms, new users, providers, and value-added processors – civil, commercial, and academic – can access a broad range of data sources much faster, and at dramatically lower cost, than prior point-to-point mechanisms. Early experiments in this domain show promise for nearer term implementation with the Earth science community and for greatly expanded understanding of the dynamic Earth. We encourage NASA to exploit the potential of network-centric operations for future exploration of our home planet.